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PTO/SB/05 (12/97)

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. 1.53(b))

Attorney Docket No.	1029/182
First Named Inventor or Application Identifier	Alicja Borysowicz, Evry, France; and Stéphane Lepert, Morangis, France
Title	APPARATUS FOR CONTROLLING GLASS MELTING AND/OR REFINING FURNACES
Express Mail Label No.	

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jc649 U.S. PTO 06/30/99

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents

ADDRESS TO: **Assistant Commissioner for Patents, Box Applications, Washington, DC 20231**

1. [X] Filing Fee as calculated below.
2. [X] Specification [Total Pages [15]]
   (preferred arrangement set forth below)
   - Descriptive title of the invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to Microfiche Appendix
   - Background of the Invention
   - Brief Summary of the invention
   - Brief Description of the Drawings *(if filed)*
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
3. [X] Drawing(s) *(35 USC 113)* [Total Pages [1]]
4. Oath or Declaration [Total Pages [2]]
   a. [X] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional with Box 17 completed)*
      [ ] DELETION OF INVENTOR(S)
      Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b)
5. [ ] Incorporation By Reference *(useable if Box 4b is checked)* The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. [ ] Microfiche Computer Program *(Appendix)*
7. Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all necessary)*
   a. [ ] Computer Readable Copy
   b. [ ] Paper Copy (identical to computer copy)
   c. [ ] Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. [X] Assignment Papers (cover sheet & document(s))
9. [ ] 37 CFR 3.73(b) Statement [ ] Power of Attorney
10. [ ] English Translation Document *(if applicable)*
11. [X] Information Disclosure Statement (IDS)/PTO-1449 [X] Copies of IDS Citations
12. [ ] Preliminary Amendment
13. [X] Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
14. [ ] Small Entity Statement(s) [ ] Statement filed in prior application, Status still proper and desired
15. [X] Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
16. [ ] Other:

17. **If a CONTINUING APPLICATION,** *check appropriate box and supply the requisite information:*
    ☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No. ____/_____

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ABSTRACT OF THE DISCLOSURE

Apparatus for controlling glass melting and/or refining furnaces

Device for controlling the melting of the glass batch in a glass melting furnace, which automatically carries out all or some of the set of operations for controlling the operating parameters of the furnace as well as all or some of the set of operations for operating the furnace actuators, on the basis of the strategies that an operator carrying out these operations manually would employ, this device comprising :

- an analysis and control device, of the fuzzy-controller type, using a control algorithm of the fuzzy-logic type which receives all the information relating to the operation of the furnace coming from the sensors and from the detection means provided on this furnace, as well as the set point values input manually by the operators, this control algorithm delivering control signals to the various actuators and control means of the furnace ; and
- a predictive system, of the neural- and/or fuzzy-type which, depending on the state of the furnace and on the information about the change in production over time, defines the various set point values to be assigned to all the furnace actuators, so as to ensure optimum operation for each production phase, the said set point values constituting input values for the fuzzy-logic algorithm which controls the furnace.

The present invention relates to the control of glass melting furnaces for the purpose of automating their operation, including during transient phases, of improving the quality of the glass produced and of reducing the consumption of fuels as well as the amount of pollutants that are discharged. This invention may be applied to any type of glass melting and/or refining furnace, namely firing, end-fired or cross-fired, electric or mixed (flame + electric) furnaces, and to any type of glass produced.

The present invention therefore aims to provide a device for controlling the melting of the glass batch, of the fuzzy control type, designed so as to automatically carry out all or some of the set of operations for controlling the operating parameters of the furnace as well as all or some of the set of operations for operating the actuators which control the equipment of the furnace, on the basis of the strategies that an operator carrying out these operations manually would employ.

It is known that the control of a glass furnace is a particularly tricky and complicated operation, especially because of the very large number of parameters involved in controlling the furnace and the considerable inertia of these furnaces, as well as the very slow variation in the parameters and phenomena involved in controlling the melting of the glass.

It follows that the control of glass furnaces often remains empirical, being generally limited to adjustment of the furnace crown temperatures by acting manually on control devices which act on the actuators which control heating and cooling equipment of the furnace and on the equipment for feeding it with the glass batch. These actions generally rely on the experience of the operator as well as on his analysis of how the furnace and the melt that it contains are behaving, in particular his visual estimation of the

conditions in which the melting and/or refining of the glass composition inside the furnace is/are taking place.

It follows from this empiricism that the principle on which to make decisions about actions to be taken with regard to a given situation in the furnace is difficult to formalize.

To solve this problem, operators generally draw up tables giving the status of all the measurable parameters of the furnace, in a given production configuration, so as to try to reproduce these parameters in a similar production situation. The number of parameters involved and the lack of knowledge about their relationship or interactions make this operation complicated during steady operation of the furnace. It is even more difficult during transient phases, such as a change of production or a change of colour, for example. Thus it may be imagined that a glass furnace can only be controlled by skilled operators with a great deal of experience.

The decisions taken therefore often depend on the experience or common practices of each operator and it follows that any generalization of the furnace control principles is extremely difficult. The operators, in their control of the furnace, work to within a safety factor with respect to the optimum operating conditions so as not to risk degrading the quality of the glass, this procedure limiting the efficiency or performance of the furnace.

The manual mode of controlling the glass furnace proves even more limited when managing the transient phases which correspond to changes in tonnage of the furnace or to changes in the type or colour of the glass, or other such changes.

Reference will now be made to Figure 1 of the appended drawings, which shows, diagrammatically, in perspective and with partial cut-away, one embodiment of a glass melting furnace to which the present invention may be applied.

This furnace, in a known manner, mainly consists of a tank 1, made of refractory materials, in which the glass 2 is melted. This tank has side walls 3 made of refractory materials and a crown 4. The chamber of the furnace is heated using burners 5 which are set in at least one of the walls of the furnace.

The melted and refined glass is temperature-conditioned, in a zone of the furnace generally called a working chamber 6, and is then delivered to the forming equipment represented schematically by the reference 7, which may be of any known type, especially machines for forming hollow glassware (bottles) or equipment for forming glass sheet for the purpose of obtaining flat glass (window glass).

The glass batch is introduced into the furnace via one or more devices of the batch charger 8 type, which are set into one or more of the walls of the furnace, these devices depositing and pushing the glass batch on the surface of the molten glass, in the form of independent batch piles or of a blanket 9 of defined composition.

The walls 3 of the furnace furthermore include a number of openings (not shown in the drawing) so as to allow the operators to observe the melting of the glass in the furnace chamber, the shape of the burner flames, the spreading of the batch on the surface of the glass melt, the operation of the bubblers, etc.

The furnace furthermore includes a number of sensors and detection means for measuring the operating parameters of the furnace and of its peripheral equipment, such as the working chamber 6, the fuel and oxidizer circuits, the fume circuits, the cooling circuits, all the fluid circuits, as well as the positions of the actuators (control valves, devices for varying the electrical power, etc.), position-control members, and other such devices. The values thus measured correspond to each state of the observed quantity or parameter (temperatures, flow rates, pressures, speeds, positions, etc.).

Starting from this state of the art, the present invention is intended to provide a device for monitoring and controlling the melting and/or refining of the glass batch in a glass melting furnace, which automatically carries out all or some of the set of operations for controlling the operating parameters of the furnace as well as all or some of the set of operations for operating the actuators of the furnace, on the basis of the strategies that an operator carrying out these operations manually would employ. The device forming the subject of the present invention is characterized in that it comprises:

- an analysis and control device, of the fuzzy-controller type, using a control algorithm of the fuzzy-logic type which receives all the information relating to the operation of the furnace coming from the sensors and from the detection means provided on this furnace, as well as the set point values input manually by the operators, this control algorithm delivering control signals to the various actuators and control means of the furnace and,

- a predictive system, of the neural- and/or fuzzy-type, which, depending on the initial state of the furnace and of its parameters and on the modification of at least one of the said parameters, determines the predicted change over time of the state of the furnace and of its parameters, this predicted change in the state of the furnace being used as input data for the fuzzy controller which determines the new set point values for the furnace actuators which are necessary for maintaining optimum operation of the furnace compatible with the defined objectives.

This predicted change in the state of the furnace and of its parameters forms part of the input data for the controller of the fuzzy-logic type which will determine the set points that have to be applied to the various actuators for operating and controlling the equipment of the furnace so as to maintain the objectives defined by the operator, such as, for

example, the crown temperatures or the quality of the glass produced.

According to a second embodiment of the control device forming the subject of the present invention, this device furthermore includes a learning or computing device which is used during the learning phase of the neural- and/or fuzzy-type predictive system, i.e. during the phase of acquisition of the operating laws of the furnace. According to the invention, this learning, determining or computing device uses a computer model of the numerical-model type making it possible to define the laws governing the operation of the furnace, either from the learning phase of this predictive system, on the actual furnace, or by simulating the operation of the furnace using a mathematical model.

According to a preferred embodiment of the device forming the subject of the invention, this device furthermore includes a means for the acquisition and processing of the image of the inside of the furnace, operating in the visible, infrared or other spectrum, the said means possibly consisting of a system of video cameras positioned in the furnace in order to observe zones corresponding to a phenomenon relating to the melting and/or to the refining of the glass, the images thus obtained then being processed so as to obtain information relating to the observed phenomenon, this information being shaped for the purpose of being introduced as input data for the furnace control algorithm so as to monitor and control the observed phenomenon.

Other features and advantages of the present invention will emerge from the description given below with reference to the appended drawing which illustrates one embodiment thereof, given by way of example and devoid of any limiting character.

In the drawing:

- Figure 1 is a diagrammatic view, in perspective with partial cut-away, showing an example

of a glass melting furnace, described above, to which the present invention may be applied, and

- Figure 2 is a flow diagram illustrating the control device forming the subject of the present invention.

As explained above, the device according to the invention provides a system for monitoring and controlling the melting and/or refining of the glass batch, making it possible to automatically carry out all or some of the operations for controlling the operating parameters of the furnace and for operating its actuators on the basis of the strategies employed by an operator carrying out these operations manually.

According to this device, the following are employed:

- an analysis and control device of the fuzzy-controller type and

- a predictive device of the neural- and/or fuzzy-type.

This device may furthermore include a learning or computing system of the mathematical-model type and a device for the acquisition and processing of the image of the inside of the furnace.

As will be understood, the control device forming the subject of the present invention relies on a control algorithm of the fuzzy-logic type, which receives the following information (this enumeration is in no way limiting):

- the temperature information obtained from temperature sensors set into or on the glass melting furnace;

- the information relating to the flow rates and pressures of the various fluids used by the furnace (fuel, oxidizer and fume, as well as their compositions, cooling, electricity) and the measurements of the consumption of each fluid, all this information being delivered by sensors or detection devices provided in or on the furnace;

- the information regarding the position of the various furnace actuators (control valves, devices for varying the electrical power, batch flow rate, etc.);

- the information from end-of-travel sensors for the furnace equipment;

- the set point values which are manually input by the operators into the furnace control system;

- the information relating to the quality of the glass produced, which information may be acquired at any point in the manufacturing process;

- the information from the neural network, as will be described in detail below; and

- the information coming from the analysis of the images of the inside of the furnace, as will be explained below.

The control algorithm of the fuzzy controller delivers control signals, especially for the following elements (without this enumeration having any limiting character):

- the combustion equipment (burners with their fuel and oxidizer feed equipment);

- the electrical equipment for heating or adjustment;

- the glass refining devices (bubblers, boost melters, etc.); and

- the furnace control systems.

The output data from this algorithm is delivered depending on the processing of the abovementioned input information and this processing is carried out according to the principles of fuzzy logic depending on the specific requirements of the system and according to the rules which govern it. These rules may either be input manually, when programming the system, or acquired by the fuzzy logic during a learning phase, directly on the furnace to be controlled.

As will be understood, the fuzzy controller gathers all the information relating to the operation of the furnace, coming from the sensors and detection

systems provided in the latter, using a fuzzy logic algorithm which reproduces the principles and the know-how of the operators so as to determine the most appropriate furnace actuator or combination of furnace actuators on which it is necessary to act in order to have optimum furnace control.

The neural- and/or fuzzy-type predictive system makes it possible, depending on the instantaneous state of the furnace and on modifications to the materials which are fed into it or on programmed modifications of at least one of its parameters, to determine the corresponding state of the furnace over the hours following the application of these modifications. In other words, this system makes it possible, depending on the state of the furnace and on the information relating to the change in the production over time, to determine, in a predictive manner, the change in the state of the furnace and the values that its various parameters will take for this step.

Thus, depending on the predicted change in the parameters describing the state of the furnace, the said predictive system will define the various set point values that have to be assigned to all the furnace actuators so as to ensure optimum operation of the furnace for each production phase. Depending on the various parameters for the production runs to be made, this predictive system determines the changes in the values of the various set points so as to optimize the transient phases. This optimization takes into account the furnace requirements, requirements relating especially to the quality of the end-product, to the operating conditions of the furnace, these being within the safety limits of its components, to the values of the consumption of the various types of energy necessary for operating the furnace, to the discharge of pollutants, to the availability of the batch materials, etc.

All these constraints are taken into account by this predictive system which, depending on the possible

situations of the furnace, as defined, determines the optimum control strategy which is put into effect by predicted set point values to be assigned to the various furnace actuators. These set point values constitute input data for the fuzzy-logic furnace control algorithm.

The control device forming the subject of the invention may also include a learning, determining or computing device which is used during the learning phase of the neural- and/or fuzzy-type predictive system, i.e. during the phase of acquisition of the operating laws of the furnace. This device, which may use a computer model of the numerical-model type, makes it possible to define the laws governing the operation of the furnace either from the learning phase of the predictive system, on the actual furnace, or by simulating the operation of this furnace using a mathematical model.

Among the information delivered to the control algorithm for the fuzzy controller is that relating to the image of the inside of the furnace. According to one of these aspects, the control device forming the subject of this invention includes means for the acquisition and processing of the image of the inside of the furnace. For this purpose, the inside of the furnace is scanned by an image-acquisition device which may consist of one or more video cameras operating in the visible, infrared or other spectrum. These cameras are positioned in the walls or in the crown of the furnace so as to provide surveillance of one or more zones corresponding to a phenomenon relating to the melting and/or to the refining of the glass. These phenomena may be:

- the distribution of the batch fed into the furnace, of the position of the batch piles, of their speed and any other parameter relating to the appearance of the batch as it melts on the surface of the glass melt;

- the operation of the burners, especially the shape and the distribution of the flames from the burners inside the furnace, so as to control the distribution of thermal power to the glass and to limit the wear of the superstructure refractories, such as the refractories of the walls and the crown of the furnace;

- the movement of the convection currents in the glass melt, especially for the purpose of optimizing the melting and/or refining of the glass in order to control its quality and to limit the wear of the refractories making up the tank for holding the glass in the furnace;

- the operation of the bubblers; and

- any phenomenon that may be observed inside the furnace.

The images thus obtained are processed by electronics or by computing so as to extract information relating to the phenomenon observed. This information is used so that it can be introduced as input data for the furnace control algorithm so as to monitor and control the phenomenon observed, thus making it possible to perform an automatic analysis of the phenomena occurring inside the furnace in that part where melting and/or refining of the glass takes place.

The capabilities of the computer are used to integrate the processing of many parameters specific to the glass melting and/or refining process, something which is impossible at the present time using manual methods of controlling glass furnaces.

Among the advantages offered by the present invention, namely the automatic furnace control device forming the subject of the invention, mention may especially be made of the following:

- furnace control is made independent of subjective perception by the operators and of their experience;

- incorporation of all of the parameters of the glass-melting process, as well as the interaction of these various parameters;

- optimization of furnace control;

- better stability of furnace operation;

- better control of transient phases;

- better control of combustion, and therefore of consumption and discharge of pollutants;

- better burner flame control;

- better control of the distribution and delivery of power into the various zones of the furnace, and therefore of the glass refining;

- optimum distribution between the various sources of energy supplied to the furnace, for example between fossil-fuel energy and electrical energy;

- better use of glass-refining tools, such as bubblers or electrical boost melters for refining;

- reduction in refractory wear by controlling the convention currents in the glass, thereby making it possible to extend furnace lifetime;

- better control of end-product quality and improved end-product quality;

- better repeatability of furnace adjustments for equivalent production runs;

- reduced energy consumption; and

- reduced discharge of pollutants into the atmosphere.

Of course, it remains the case that the present invention is not limited to the embodiments described and/or shown here, rather it encompasses any variant thereof falling within the scope of the invention, as defined by the appended claims.

CLAIMS

1. Device for controlling the melting of the glass batch in a glass melting furnace, which automatically carries out all or some of the set of operations for controlling the operating parameters of the furnace as well as all or some of the set of operations for operating the furnace actuators, on the basis of the strategies that an operator carrying out these operations manually would employ, this device comprising :

- an analysis and control device, of the fuzzy-controller type, using a control algorithm of the fuzzy-logic type which receives all the information relating to the operation of the furnace coming from the sensors and from the detection means provided on this furnace, as well as the set point values input manually by the operators, this control algorithm delivering control signals to the various actuators and control means of the furnace ; and

- a predictive system, of the neural- and/or fuzzy-type which, depending on the state of the furnace and on the information about the change in production over time, defines the various set point values to be assigned to all the furnace actuators, so as to ensure optimum operation for each production phase, the said set point values constituting input values for the fuzzy-logic algorithm which controls the furnace.

2. Control device according to Claim 1, furthermore including a learning or computing device which is used during the learning phase of the neural- and/or fuzzy-type predictive system, i.e. during the phase of acquisition of the operating laws of the furnace.

3. Control device according to Claim 2, wherein the learning or computing device uses a computer model of the numerical-model type, making it possible to define the laws governing the operation of the furnace, either from the learning phase of the said predictive system, on the actual furnace, or by simulating the operation of the furnace using a mathematical model.

4. Control device according to Claim 1 further including a means for the acquisition and processing of the image of the inside of the furnace, operating in the visible, infrared or other spectrum, the said means possibly consisting of one or more video cameras positioned in the furnace in order to observe zones corresponding to a phenomenon relating to the melting and/or to the refining of the glass, the images thus obtained then being processed so as to obtain information relating to the observed phenomenon, this information being shaped for the purpose of being introduced as input data for the furnace control algorithm, so as to monitor and control the observed phenomenon.

5. Control device according to Claim 4, wherein said phenomenon observed by the means for acquisition and processing of the image of the inside of the furnace is the distribution of the glass batch fed into the furnace, of the position of the batch piles and of their speed, as well as various parameters relating to the appearance of the batch as it melts on the surface of the glass melt.

6. Control device according to Claim 4, wherein said phenomenon observed by the means for acquisition and processing of the image of the inside of the furnace is the shape and the distribution of the flames from the burners inside the furnace, so as to control the distribution of thermal power and to limit the wear of the refractories, especially of the walls and the crown of the furnace.

7. Control device according to Claim 4, wherein said phenomenon observed by the means for acquisition and processing of the inside of the furnace is the movement of the convection currents in the glass melt, especially for the purpose of optimizing the melting and/or refining of the said glass in order to control its quality and to limit the wear of the refractories making up the tank for holding the glass in the melting furnace.

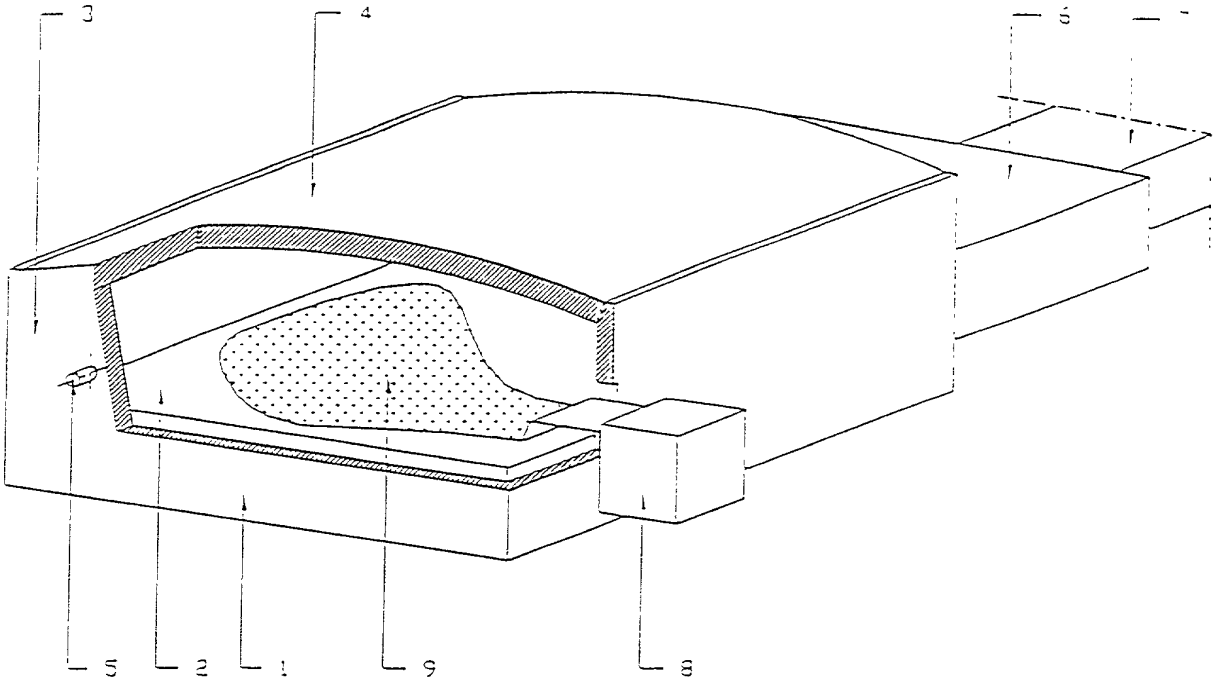
8. Control device according to Claim 4, wherein the phenomenon observed by the means for acquisition and processing of the image of the inside of the furnace is the operation of the bubblers.

9. Control device according to claim 1, wherein the predictive system of the fuzzy-logic or neural type is designed so as to deliver information used by the fuzzy controller for defining the set points that have to be applied to the

various actuators for operating and controlling the furnace equipment, depending especially on the modifications to the production program or modifications to the materials fed into the furnace.

5

FIG. 1


3
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2
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9
8

FIG. 2

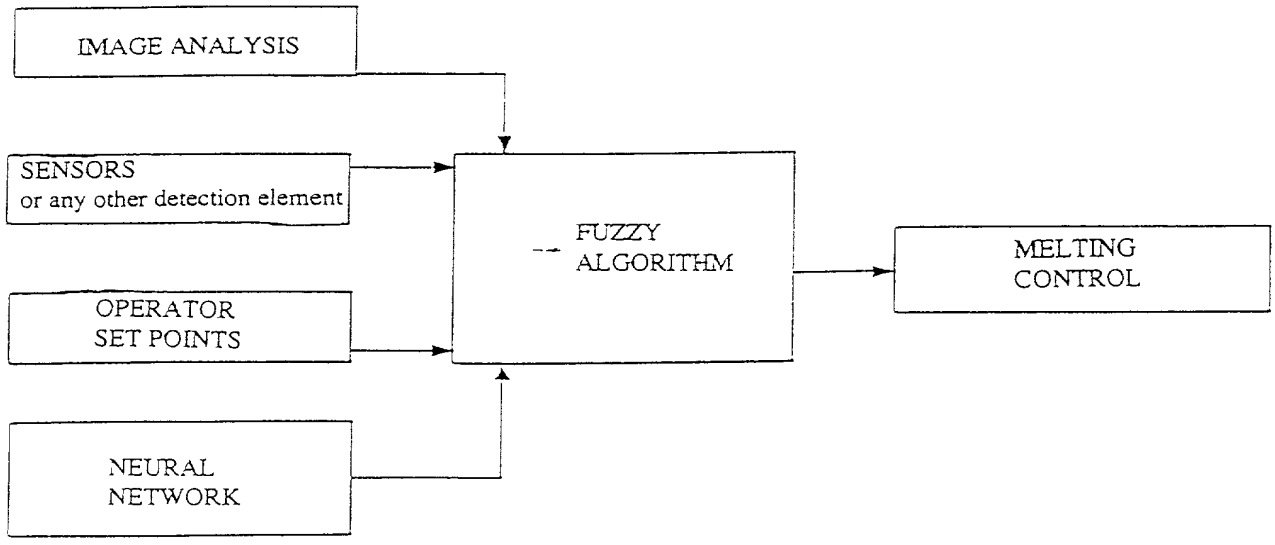
IMAGE ANALYSIS
SENSORS
or any other detection element
OPERATOR
SET POINTS
NEURAL
NETWORK
FUZZY
ALGORITHM
MELTING
CONTROL

DECLARATION FOR PATENT APPLICATION

As a below-named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

_____

the specification of which: (check one)

[XX] is attached hereto [ ] was filed on _____19___, as United States Patent Application Serial No. or PCT International Application Number _____, and was amended on _____19___ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with 37 CFR § 1.56(a).

Prior Foreign Application(s): I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate listed below, or § 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

			Priority Claimed
98 09706 (Application No.)	FRANCE (Country)	July 29, 1998 (Day/Month/Year Filed)	[X] [ ] Yes No
_____ (Application No.)	_____ (Country)	_____ (Day/Month/Year Filed)	[ ] [ ] Yes No
_____ (Application No.)	_____ (Country)	_____ (Day/Month/Year Filed)	[ ] [ ] Yes No

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below:

Application No.	Filing Date
_____	_____
_____	_____

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by 35 U.S.C. § 112, first paragraph, I acknowledge the duty to disclose material information as defined in 37 CFR § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

_____ (U.S. Application Serial No.)	_____ (U.S. Filing Date)	_____ (Status--patented, pending, abandoned)
_____ (U.S. Application Serial No.)	_____ (U.S. Filing Date)	_____ (Status--patented, pending, abandoned)

I hereby appoint Elliott I. Pollock, Registration No. 16,906; George Vande Sande, Registration No. 17,276; Burton A. Amernick, Registration No. 24,852; Stanley B. Green, Registration No. 24,351; Richard Wiener, Registration No. 18,741; Townsend M. Belser, Jr., Registration No. 22,956; Morris Liss, Registration No. 24,510; Martin Abramson, Registration No. 25,787; George R. Pettit, Registration No. 27,369; Elzbieta Chlopecka, Registration No. 32,767; Eric J. Franklin, Registration No. 37,134; and Jeffri A. Kaminski, Reg. No. 42,709, my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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DECLARATION FOR PATENT APPLICATION

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Inventor's Signature _____ Date _____

Residence Address _____

Citizenship _____

Post Office Address _____

Full name of fourth joint inventor (if any): _____

Inventor's Signature _____ Date _____

Residence Address _____

Citizenship _____

Post Office Address _____

Full name of fifth joint inventor (if any): _____

Inventor's Signature _____ Date _____

Residence Address _____

Citizenship _____

Post Office Address _____

Full name of sixth joint inventor (if any): _____

Inventor's Signature _____ Date _____

Residence Address _____

Citizenship _____

Post Office Address _____

Full name of seventh joint inventor (if any): _____

Inventor's Signature _____ Date _____

Residence Address _____

Citizenship _____

Post Office Address _____

Full name of eighth joint inventor (if any): _____

Inventor's Signature _____ Date _____

Residence Address _____

Citizenship _____

Post Office Address _____